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RADIUM

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VOL. V JULY, 1915 No. 4

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A MONTHLY JOURNAL DEVOTED TO THE CHEMISTRY PHYSICS AND THERAPEUTICS OF RADIUM AND RADIO-ACTIVE SUBSTANCES

RADIUM

A MONTHLY JOURNAL DEVOTED TO THE CHEMISTRY, PHYSICS AND THERAPEUTICS OF RADIUM AND RADIO-ACTIVE SUBSTANCES.

Edited and Published by Charles H. Viol, Ph. D., and William H. Cameron, M. D. with the assistance of collaborators working in the fields of Radiochemistry, Radioactivity and Radiumtherapy.

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VOL. V. JULY, 1915 No. 4

THE MODERN TREATMENT OF CANCER*

JOHN M. LEE, M.D., ROCHESTER, N. Y.

When we recall the criticisms that are to be found in the daily papers and magazines respecting radium, we are reminded of the struggle Ephraim McDowell went through in the early days of abdominal section for the cure of ovarian tumor. In referring to some of Dr. McDowell's reports a prominent French surgeon of those days says: "In spite of all that has been written respecting the cruel operation, we entirely disbelieve that it has been performed with success, nor do we think it ever will." For a long time this was the prevailing sentiment regarding Dr. McDowell's operation which has added ten years to the life of woman, and similar remarks have been employed at first towards almost every advancement in surgery. For instance, hysterectomy was abandoned for many years, then taken up again and pushed to perfection in spite of almost unprecedented opposition.

When surgeons were convinced, twenty-eight years ago, that inflammation of the bowels and peritonitis caused thousands of deaths, preventable by timely removal of the appendix, you remember how bitterly that operation was opposed and how often members of our societies exclaimed at the top of their voices: "The surgeons do their work with mercenary motives!" To-day, all of these operations are recognized as regular procedures; in fact, if they are not done early even the laity censure their medical attendants.

This opposition has been the rule with most advancement, whether among laymen or the professions, and medicine and surgery have been gallant leaders in their attacks upon what later, even they acknowledged to be the best method of treatment. The effects of radium upon such

*Read by invitation before the Homeopathic Medical Society of the State of Michigan, 46th Annual Session, May 18, 1915, at Detroit, Mich.

deadly diseases as cancer are so startling that it is no wonder that men who have not had the opportunity to investigate the subject believe that it is another of the numerous fake cures for the red plague, and that it is only a kindness to warn people against submission of their cases to those over enthusiastic if not misguided doctors.

Comparatively, it is only a few years since the discovery of radium; its use in surgery is still more recent; and why should it not also receive, during its developmental period, its full share of persecution and condemnation? This great advancement in cancer therapy ranks with anaesthesia, antisepsis or any other of the great epoch making developments in surgery, and like these it has had its months and years of purification by earnest discussion. During this process of winnowing out the chaff it is no wonder that the use of the agent was largely laid aside for a time because the methods of application were not sufficiently well understood to enable experimenters to secure the desired results.

Then again, many of the preparations employed by the physicians were not up to the present standard. In those days there was no standard, and in some instances where it was supposed that a goodly amount of radium was purchased, only a few milligrams were actually obtained. Whether this was due to dishonesty or lack of instruments of accuracy for measurement of the strange metal, failure was bound to follow this use of insufficient dosage.

With the lapse of years better methods have been developed, accurate instruments of measurement have been invented; the indications for the use of the agent have been narrowed down until one need not often disappoint his patients by holding out claims which have not and cannot be verified. It may be said, however, even to-day, that many of us take patients whose cases are forbidding; still the pain from which they suffer, the hemorrhages and discharges, the unpleasant odors, may all disappear under its influence and the patients be brought into a more comfortable condition. While a cure is out of the question in many of these cases, the relief is such that we may feel that there is no other means that can in any way equal the beneficial results secured even in these hopeless cases. To say that we are surprised at the results of the agent is too weak a word, we are amazed: wide sloughing surfaces, even including bone and cartilage, are cleaned up, the wound brought into a healthy state and completely healed. Tumors are dissipated and the patients' comfort and lives are prolonged far beyond a point possible to be secured by any other treatment. Indeed, if radium can achieve no greater success than to lessen the frightful pain and other conditions attendant upon the disease, it would be glory enough. But as a matter of fact many, many cases that are classed as inoperable and hopeless are actually cured.

I do not say now that the old methods of surgery should be laid aside. Far from it. The indications should be carried out early; patients should be secured during the first three to six months of the existence of cancerous disease, then most appropriate operations would result in cures; but, unfortunately, neither the profession or the laity are sufficiently educated as to the necessity of early operations. Too many of us are apt to say, "It is only a little lump;" and the patients are allowed to drift on until the disease becomes wide-spread in the glands and different parts of the body. Then of course it is a question of palliation and prolongation of life.

There is also a strange notion among women that it is disgraceful to have a tumor of the breast, and for this reason, or some other, they cover up the presence of such disease and do not allow even their nearest rela-

tives or friends to know of it, until they are driven to the surgeon by a fetid discharge, sleepless nights or severe pain. Such a condition as this in these days of well nigh perfect surgery and radium-therapy ought rarely to exist.

I am aware that we are carrying on a campaign over the country to correct this gross neglect; but the wheels of progress move so slowly that the time is far distant when malignant disease will receive attention sufficiently early to secure the best results of the surgeon's art.

Now for all these reasons, patients sometimes get into the inoperable state almost unthinkingly, especially where the disease carries with it but little pain. In many inoperable cases radium is the best palliative and sometimes curative agent.

The Harvard Cancer Commission states that metastatic cancer should never be treated by radium. This is too sweeping a statement for scientific purposes. When the disease redevelopes in the liver, the lungs, the stomach or other abdominal viscera very likely relief cannot be had even by the use of this potent remedy; but when it develops by metastasis upon the surface of the body, as from the arm to the face or the face to the leg, etc., the condition is very different, as in these sites the remedy may be used with great success at least as a palliative.

I herewith present a number of illustrative cases of this form of the disease:

CASE 1. A. W. C., Irish, aged 65, residence Rochester, about three years ago developed epithelioma of the wrist. Ten months later a metastatic growth appeared on the upper lip and developed until this part of the anatomy, the corners of the mouth, the upper teeth and a portion of the nose including the external nares were completely destroyed. Then it reappeared three inches above the first manifestation on the wrist; a few months later on the elbow; then again a few inches above this site. A cough developed, expectoration was difficult, and progressive dullness with deficient respiratory murmurs over a portion of the left lung announced metastasis to this organ. He had had gonorrhea but there was no history of syphilis and the Wasserman reaction was negative. By the use of radium the lip healed, some of the bone of the upper jaw and teeth sloughed away and this part was brought into a good condition.

The three developments in the arm are now entirely healed and the original cancerous deposit in the wrist has been cleaned up and the edges of the wound are healing. The apnea and the profuse hemorrhages from the corners of the mouth, the foul odors and ichorous discharges have all subsided and the general condition of the patient is greatly improved. There is no other agent with which we could accomplish this result, and if the case progresses no farther, the use of the agent was not only justifiable but a source of incomparable relief to the patient.*

CASE 2. Mrs. J. L., American, aged sixty-seven, residence Canton, N. Y., developed epithelioma on the bridge of her nose about six years ago, which broke down and remained as a rodent ulcer. Last June a growth appeared on the left side of her neck and the disease grew worse until the latter part of December, when a competent consulting surgeon told her no hope could be expected from any treatment whatsoever. On January 9, 1915, Dr. Williams, of Canton, her family physician, brought her to the Lee Private Hospital, and our examination developed the following facts: On entering the room the heavy cancer odor was discernable, and markedly so when drawing near the patient. A glass of milk was offered and it required three efforts at deglutition to swallow

*Has since died with hemorrhage of the lung and apnea.

a teaspoonful. With great difficulty she could be heard in a whisper only eight inches from her lips. She looked like a patient *in extremis* from serious disease, and her breathing was so embarrassed that prompt measures were required to prevent dangerous consequences. Fifty milligrams of radium element was applied over the larynx and top of the esophagus. Part of this dosage was used on one side and the balance on the other, as nearly over the entrance to the larynx and esophagus as was possible. In the morning she breathed easier and could swallow with much more freedom. This improvement was sustained and at the end of the first week the heavy odor from her breath ceased and the salivation and bloody ichorous discharge were very markedly less. She was now able to take milk with comparative freedom and her physical condition was perceptibly improved.

On January 9, 1915, Dr. Herbert W. Hoyt of this city made a careful examination of her larynx, pharynx, etc., and the following is a copy of a letter which gives a report as to his findings at that time:

"Jan. 9th, 1915.

"Dr. J. M. Lee,
"Rochester, N. Y.

"Dear Doctor Lee:—

"On Dec. 21st, 1914, I examined the throat of Mrs. Lovewell at your hospital. I found very marked ulceration and infiltration of both vocal cords, the arytenoids, the rim of the glottis, the laryngo-epiglottic folds on the left and the lower edge of the epiglottis on the left. It was very difficult to see any opening through the larynx. Jan. 4th, 1915, I examined her again. I found the infiltration very much less, the ulcerated surface, save one small area on the right rim of the glottis, smooth and apparently covering with mucous membrane. There was a fair space through the larynx though not enough to determine how much of the vocal cords remain. There is a small notch in the left side of the base of the epiglottis. The parts all looked in a much healthier condition. While there was no power to vocalize at the first examination at the second she had a fairly strong rough voice.

"Yours very truly,
H. W. Hoyt."

The radium treatment was repeated for four nights and about six thousand milligram hours radiation (radium element) was used in the treatment of her case. After about a week a fine reaction appeared around the throat and with this the improvement continued and became marked. No more radium was used, and on the 4th of February Dr. Hoyt made a third laryngoscopic examination and a letter of his findings is here transcribed:

"Feb. 4th, 1915.

"My Dear Doctor Lee:

"As a supplement to my last report on the condition of Mrs. Lovewell I will report the findings of examinations Jan. 18th and Feb. 2nd. The larynx is more open to view and the surfaces are smoother save in two spots. On the right rim of the glottis in January there was a large nodular mass of tissue, this was much smaller, with a shriveled look on Feb. 2nd. In general the whole area had a healthier appearance at the

last examination than at any other time. The voice remained about the same but she swallowed freely without any choking.

"Yours truly,

H. W. HOYT."

At this time it was believed that she was not improving as fast as she might, and about three thousand more milligram hours radiation (radium element) was employed. But little attention was paid to the tumor on the side of the neck, as her symptoms were so urgent that it seemed wise to devote our attention entirely to the internal disease. A week or so later a heavy dose was applied to the tumor and a marked improvement is taking place. Of course how far this happy result will be sustained is impossible now to tell, but with the other methods of treatment with radium open to us it is fair to assume that good results will finally be secured.*

CASE 3. Mrs. J. C., aged eighty, of Riga, N. Y., about twelve years ago noticed a growth in the left temporal region. A few years later a tumor developed on the upper lip, spread over the entire vermilion border, the inner surface, the buccal cavity on the left side and half of the palate. After the lapse of six or seven years it was removed by the knife at St. Mary's Hospital, this city. It grew rapidly and two years thereafter her family physician removed the portion on her lip by tying and caustic but did not attempt operation of the internal disease. About the middle of September, 1914, she came to a Rochester physician and took X-ray treatments, one each week for a period of five weeks. There was no improvement but on the contrary much inflammation and swelling, which caused great discomfort. She came to this hospital and radium treatment was begun on Nov. 19, 1914. Forty milligrams of radium element was applied to the vermilion border, or what once was such, and the inside of the lip. This cross-fire method caused the disease to promptly disappear. A week later 25 milligrams of radium element was applied to the palate, the disease yielded and the progress towards recovery was uneventful and satisfactory. The rodent ulcer in the temporal region was cured by a single application of 10 mgm. radium in a half strength varnish applicator. The disease has entirely disappeared and she has returned to her home clinically cured.

CASE 4. E. A. Y., American boy eight years of age, of Corry, Pennsylvania, developed sarcoma of the left orbit and temporal region. On November 22, 1914, Dr. Wagoner, an oculist, removed a growth from the side of the left temple and orbit. Soon thereafter the parts became swollen and malignant disease was suspected. The removed specimen was sent to a pathologist who reported the disease to be round cell sarcoma. A more extensive operation was thought necessary and on December 22nd the eye was extirpated and the orbital tissues removed. Soon the disease reappeared and he was sent to this hospital on January 13, 1915, for radium treatment. During his four days' stay at the hospital he received 4,004 milligram hours radiation (radium element). The growth in the temporal region began immediately to subside and the tissues in the orbital region appeared to be sufficiently rayed and he went home. When he returned to the Hospital on the first of March, the swelling in the temporal region had entirely disappeared but there was some of the growth still to be seen in the orbit. He remained four days and received 7,466 milligram hours radiation (radium element), which

*Died suddenly, while improvement was satisfactory, of pulmonary embolism.

seems to have eradicated the disease. He returned to the Lee Hospital again five weeks later when it was shown that he was clinically cured.

CASE 5. Mrs. S. de W., French Canadian, forty-four years of age, residence Rochester, N. Y., last June developed a growth near the center of her under lip and applied to a physician who prescribed an operation, which was performed last October. Almost immediately thereafter a bunch appeared in her neck which the same physician said was an enlarged gland. He removed it, when to her surprise and dismay the disease began to grow rapidly in the scar on her lip and it appeared over her sternum on the left side, just above the breast, in the form of an oval tumor which resembled in size and shape half of an orange. Her physician then announced that the disease was a malignant form of cancer and that it had gone beyond the reach of the knife; therefore he sent her to this hospital the night before Thanksgiving and radium was immediately applied to all the above surfaces.

During the two weeks she remained here 4,000 milligram hours radiation (radium element) was employed. She returned home and again visited the Hospital New Year's eve and remained a week. During this time 3,000 milligram hours radiation (radium element) was employed, and she returned to her home for the second time on February 10th and remained until the last day of February when she again came for further treatment. She has never had any pain from either the growth on her neck or lip, and suffered very slightly from the inconvenience caused when applied to both the inner and outer sides of her lip. She has since been discharged as clinically cured.

CASE 6. M. W. P., American, aged sixty-eight, residence East Pembroke, N. Y., developed a brown spot near his right ear which broke down and formed an irregular ulcer an inch and a half long and an inch wide. A Buffalo specialist applied electric needles and the ulcer finally healed. There was great pain following its closure and soon small tumors developed behind, below and in front of the ear, the pain of which became so excruciating that it was necessary to make hot applications and resort to the use of morphine for relief. His physician, Dr. Baker of Batavia, referred him to this hospital for treatment. His suffering then was so extreme that it was impossible for him to restrain the outcries of pain which could be heard all over the hospital. After the effects of the radium were established the morphine was discontinued and he was able to get along without it very comfortably. Three weeks later the tumors had entirely disappeared and two weeks thereafter the effects of the radium upon the skin subsided and he appears to be in a normal condition. In the patient's own language: "It was surprising how the tumors melted away under the influence of the radium."

Radium is also of great value as a prophylactic. The application may be made over the scar and in all directions around it; a large area of tissue should be included and the cancerous elements, whatever they are, destroyed. This gives to many patients immunity from the disease. In other instances where cancer has been removed, especially if any of the growth has been left, an aseptic tube containing twenty-five milligrams of radium element, screened by a lead tube,* should be introduced into the end of the rubber drainage tube and carried down to the depth of the wound and allowed to remain in this site two hours; then if the wound is large, as in a breast operation, it should be drawn down part way and left two hours more. It should not act longer on the tissues

*In several cases we have had tardy union following the use of radium with the lead tube. Of late it has been left off and the wounds have healed much better.

as there may be too much sloughing, as in my first case. It was sarcoma of the femoral canal, and in the removal of the growth several inches of the femoral vein were included with the tumor. Twenty-five milligrams of radium element were used as above and left eight hours. There was too much sloughing and three weeks after the operation about four inches of the vein, including the tied end, came away. No ill consequences followed except a little more swelling of the leg, which has now subsided and the patient attends to her duties as housewife. Since that time I have treated two cases of sarcoma and carcinoma, respectively, of the neck over the jugular veins. The dissections were very thorough. The veins were tied above the tumors and the mass dissected downward, when it become necessary to divide the clavicles and retract them so as to make room to complete the work and tie the vessels near their origin. When the growths were completely removed, a tube containing 25 milligrams of radium element was placed in the end of the drainage tube in each case and carried down to the bottom of the wounds and allowed to remain four hours—which seemed to be ample.

In two other instances in the extirpation of recurrent axillary glands, two hours of raying, using 25 milligrams of radium element, was satisfactory.

It will necessarily take considerable time to determine the real value of prophylactic treatment, but I am convinced that with such wonderful curative powers as radium possesses, its inhibitive effect immediately after operation or after the wounds have healed, will prove to be one of the greatest benefits derived from the use of the element. There has been considerable work done in this way by many, both here and abroad, and the results are very encouraging; but time has not elapsed for the collection of statistics sufficiently massive to enable us to decide all details of this very important question. At the present time, if patients desire it, they are given one or the other of the above forms of preventive treatment at this hospital. The time may not be far distant when we will feel that it matters not whether operations are done early or late; whether cancerous tissue is known to be left behind or not, radium should be used as a prophylactic either before or after the wounds heal.

I have herein cited eleven cases which were inoperable and hopeless, for in three of these without radium to supplement the surgical work I should not have attempted any serious procedures. Of this number six are clinically cured. Truly, as Dr. Kelly says: "Radium is the handmaid of surgery."

ROENTGEN-RAY KERATOSES ON HAND OF ROENTGENOLOGIST CURED BY RADIUM*

SINCLAIR TOUSEY, A.M., M.D., NEW YORK.

My own hands had long been disfigured by these growths which resulted from my Roentgen-ray work and which occasioned some anxiety from the fact that many of my acquaintances in this specialty had developed fatal cancer from a similar origin. The lesions were of two types.

*Case exhibited before the New York Roentgen-Ray Society, Jan. 12, 1915, and the Surgical Section, New York Academy of Medicine, Feb. 5, 1915, and reported at the Western Section of the American Roentgen-Ray Society, Chicago, March 3, 1915. Reprinted from Journ. Am. Med. Assn. April 24th, 1915, p. 1394.

A very few were raised, almost pedunculated, healthy looking fleshy tumors with a black pigmented apex. About thirty others were exceedingly hard black lumps projecting slightly above the surface of the skin. The smaller ones of this type had a tendency to undergo spontaneous exfoliation about once a year, leaving a healed surface somewhat depressed but surrounded by an indurated base. In a very few days a deposit of pigment granules would take place looking, under a magnifying glass, like particles of anthracite coal and in a week or two the black lump would have been renewed. The smaller lumps of this type could be curetted out at any time, leaving a dry, reddish, granular depression on which a similar growth was quickly reproduced. There were a few larger ones of this type which never came away spontaneously and which looked as if the bone would almost be exposed if they should be curetted out. Some of these were associated with deep painful fissures of the skin.

Eleven years ago, that is, in 1904, one of this type was removed by circular incision extending deeply into the flesh and not of a nature to be closed by suture, but being left to heal by granulation. This was examined microscopically and found not to be malignant. There remains to this day a small white indurated cicatrix.

For years I used to keep these unsightly excrescences under some kind of control by application of salicylic and lactic acids, which removed them temporarily. Another application which was not permanently successful was formaldehyd in 40 per cent. solution. About a year ago, at the suggestion of a general surgeon, two of the larger growths were treated with pyrogallic acid, 1 dram to collodion 1 ounce, applied three times a day. This application was not painful at first, but later produced two terribly sore fingers with suppuration underneath the area destroyed. Eventually, the growth came away and the ulcer healed; but the growth returned in a short time and all my suffering had been in vain.

If there had been only a few of these growths they would have been excised long since; but there never seemed to be a convenient time to give up the entire use of both hands long enough to have thirty growths removed surgically.

Dr. Caldwell had succeeded in curing certain Roentgen-ray lesions on his hands with radium and I had used this material successfully in many malignant and benign conditions not due to the Roentgen ray. I was moved on Nov. 11, 1914, to give it a trial on my own hands.

I selected one of the largest growths which formed a regular horn on the dorsum of the interphalangeal articulation on the left ring finger. The field of application was limited by a contrivance of my own[1] which I have found exceedingly convenient.

The protective sheet metal is rendered adhesive by coating it with double-faced adhesive plaster. Twenty mg. of radium element enclosed in a small glass tube covered with the thinnest soft rubber, was kept almost in contact with the skin for thirty minutes. The growth had been pared down almost to the bleeding point with a scalpel.

The result of the application was not perceptible for about ten days, then the skin became somewhat red and shiny. Twenty days more passed without any further decided change. During this whole month the pared-off keratosis had not sprung up again, as would have been the case if the radium had not been applied. On the thirty-first day, however, it looked a little doubtful and just at the same time the reddened skin around its edges was discovered to be loosened from the underlying

[1]Tousey, Sinclair: Radium and Roentgen Therapy Facilitated by Double-Coated Adhesive Plaster, New York Med. Jour., Dec. 26, 1914.

tissues and in a few minutes the entire destroyed growth was removed like a scab. The surface beneath was pink and tender, but fully healed, and now, ten weeks after the radium application, the skin there is strong and presents no mark of any kind.

I have been treating all the other growths *seriatim*. Some have been slightly blistered, but even these could scarcely be called painful, though looking red and angry. They all come away in about a month, leaving a healthy surface beneath.

The histologic examination by Dr. F. E. Sondern gave the following findings:

"The gross appearance of one of the original black crusts curetted out before treatment was that of a hard cornified epithelium showing some brownish-black pigmentation of the outer exposed surface. The scales have an imbricated formation and are rather brittle in consistency. The surface that was in opposition to the skin lesion was slightly saucer-shaped and has a gray color devoid of pigmentation. Microscopic examination shows marked keratosis of the proliferated upper strata of epidermis. The pigmentation noted above is of very superficial extent. The destroyed growth which came away a month after the radium application showed no essential difference from the above except that there was much less marked pigmentation."

Evidently Roentgen-ray keratoses, while in the precancerous state, are curable by radium applications.

850 Seventh Avenue.

REVIEWS AND ABSTRACTS

Jacob Rosenbloom, M.D., Ph.D. A Study of the Urinary Nitrogen and Sulphur Partition in a Case of Rheumatoid Arthritis Treated with Intravenous Injections of Radium Salts. (From the Biochemical Laboratory of the Western Pennsylvania Hospital, Pittsburgh, Pennsylvania). The American Journal of the Medical Sciences, Vol. CXLIX, May, 1915, pp. 718-22. "It is of great interest to establish the effects of radium on metabolism. This paper contains a study of the effects of radium given intravenously on the urinary nitrogen and sulphur metabolism. But little work has been done from the metabolic standpoint. Gudzent claimed to have found a disappearance of uric acid from the blood after inhalations of air containing 2 to 4 Mache units of radium per hour. He also claimed the emanation of radium caused an increase in the solubility of sodium urate. Kreb and Lazarus found that radium emanation had no effect on the solubility of sodium urate. Kehrer claimed that radium emanation caused a mobilization of uric acid in the body. Knaffl-Lenz and Wiechowski found no increase in the solubility or decomposition of sodium urate by radium emanation. Fine and Chace found that radium administered as the bromide and inhalation of emanation in strengths as high as 100 Mache units per liter for long periods of time failed to show any influence upon the uric-acid concentration of the blood and produced no definitely increased output of uric acid in the urine. Skorzowski claimed to have found that radium therapy in the gouty leads to an increased output of nitrogen, uric acid, and neutral and oxidized sulphur."

"The patient on whom this study was carried out was the subject of a severe case of rheumatoid arthritis of many years' standing. Throughout the experiments he was placed on a constant diet, and the

methods for the estimation of the various urinary constituents were the same as those mentioned in previous communications."

Analytical results show that following the intravenous injections of 100 micrograms of radium element the urinary nitrogen shows a marked increase on both occasions. This increase persisted for about three days. The proportions of urinary nitrogen as urea-nitrogen, uric acid-nitrogen, ammonia-nitrogen, amino-acid nitrogen, creatinin-nitrogen, and undetermined-nitrogen remained about the same following the injections. The uric acid in grams and uric acid-nitrogen, both of which are of special interest, also show the non-effect of the radium on their excretion in the urine.

"Also following the intravenous injection of 100 micrograms of radium element there was produced a marked increase on both occasions in the total sulphur of the urine, and this increase persisted for three days. On the urinary sulphur partition it may be noted that a marked increase in the neutral sulphur of the urine was produced by the radium. This effect continued for about three days following the injection. This finding of effects ceasing after three days following the injection may be considered as an indication for giving the radium about every fourth day, as by this method one would be renewing the effect that it has on the metabolism."

"It will be recalled that the urinary sulphur is made up of sulphates, both inorganic and ethereal, and certain less highly oxidized compounds which are called, following Salkowski's suggestion, "neutral sulphur." The neutral sulphur compounds are many and include the following: Uroferric acid, uroproteic acid, oxyproteic acid, urochrome, thiocyanic acid and its salts, cystin and similar substances, taurin and taurincarbamic acid, methyl mercaptan, ethyl sulphid, thiosulphuric acid, and sulphurous acid."

"The effect of intravenous injection of radium producing such a marked increase in the excretion of the urinary neutral sulphur is of great interest. It will be recalled that Folin claims that the truest index to the endogenous or cellular metabolism is represented by the urinary uric acid, creatinin, and neutral sulphur. As we have found that the intravenous injection of radium in dosage of 100 micrograms has no effect on the amount of creatinin and uric acid excreted, it must be that the radium influences some part of the endogenous metabolism related to the neutral sulphur but not implicating the other two constituents. It may be that the radium effects the intracellular oxidation, thereby increasing the amount of neutral or unoxidized sulphur."

* * * * *

C. Esdra. Ten Years of Radiotherapy. Policlinico, XXII, No. 14, pp. 449-484. "Esdra has applied one or more forms of radiant energy in 933 cases of various affections, including 302 of non-maglignant tumors and 58 of cancer. The details of treatment and the results are given in tabulated form. With epitheliomas benefit was realized in all but four of the 31 cases in which radium was applied, and in five of the 11 cases under Roentgen treatment. The benefit was only transient; recurrence at the spot or at a distance followed, and the recurrences proved refractory to the rays. Epitheliomas of the lip, mouth and palate seemed to improve rapidly under radium but recurrence soon followed. The condition grew worse again so rapidly that it seemed as if the radium treatment had actually whipped it up into a fulminating course, speedily fatal. This was particularly manifest in a case of a small epithelioma of the palate of thirteen years' duration. It subsided under the radium but metastases developed almost at once in a gland nearby, and soon proved fatal. Only

in one case of alveolar epithelioma the recurrences yielded likewise to the radium treatment, but metastasis in the pleura followed a traumatism."

"With sarcoma, on the other hand, in five of the eight cases a permanent cure seems to have been realized under the radium, and in one of the seven cases given Roentgen treatment. In the eight cases of leukemia, roentgenotherapy had a palliative influence in seven and none at all in the other case. Epitheliomas not actively malignant yielded to radium or Roentgen rays in a most gratifying manner. The effect of the two seems about the same except that radium sometimes proved effectual when the Roentgen rays had failed. Only eight under radium and five under Roentgen treatment proved refractory of the 203 benign tumors; these few refractory tumors were in the fingers, tongue, bladder, or at the anus. Especially fine results were obtained in 33 cases of epithelioma of the eye-lid, only one case proving refractory. In the others even the cosmetic outcome was excellent. Radium was used in all but two of these eyelid cases. In 58 cases of warts, all disappeared promptly under radium treatment, even old chronic warts that had spread under the nails. In one case of leukoplacia, one patch subsided completely while a second patch proved absolutely rebellious. The effect realized with roentgenotherapy in chronic and subacute eczema surpassed that of any other treatment known to date. Complete cure under radium is reported in the 12 trachoma cases, six tuberculous ulcerations, and seven of cheloid acne. Most of the work reported was done at the public institution for physicotherapy at Rome of which Esdra is director." Journ. A. M. A.

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Robert Abbe, M.D., New York. Uterine Fibroids, Menorrhagia, and Radium. Medical Record, Vol. 87, March 6th, 1915 pp. 379-81 "Uterine fibroids, associated with unusual or profuse and exhausting hemorrhage (menorrhagia), are of the submucous and mural varieties."

"The immediate source of bleeding is from the hyperthrophied endometrium, which is spongy and highly vascular, or from the open-mouthed vessels whose lumen can be seen to the open on the thinned out musoca spread over the rounded surface of a tumor which bulges into the cavity of the uterus. These are easily demonstrated when a fresh section of the uterus and tumors is made immediately after hysterectomy. A little pressure squeezes out blood from the open mouths of one or more vessels. Often times thorough curettage removes the weak vessels, hemorrhage ceases and sometimes does not recur."

"More often hysterectomy has been needed to insure a cure. Medication is of not much avail, though internal administration of gallic acid, or local intrauterine swabbing, with a mixture of antipyrin and salol, often arrests severe hemorrhage."

"It is a pleasure to add an agent so simple and powerful as radium for the control of this serious malady. But, best of all is the demonstrated greater effect of its reducing power and frequent cure of the tumor itself. It is quite probable that when the exact dosage of radium and its best method of application can be certified, it will be found to be a uniformly curative agent for fibroid tumors."

"No simpler treatment can be conceived of than to introduce a thin, smooth, aseptic tube containing radium into the uterine cavity, leave it for one or two hours and watch improvement. Many patients are reduced to grave anemia, with waxy pallor, by prolonged hemorrhage, and the physician hesitates to offer the usual surgical procedure, especially when anesthesia is called for. In such types the radium treatment is a boon."

"Its earliest known application was in 1905 for bleeding fibroids in one of my own cases. My experience of the previous two years in using strong radium in many surgical conditions and in highly vascular naevi showed the truth of the claims of Wickham that obliterative endarteritis followed its use, and led me to hope that intrauterine vascularity would be altered by it."

"In December, 1905, I was confronted by a case of extreme anemia from fibroid menorrhagia in which it seemed unwise to operate. The patient, a physician's wife, was forty-four years old. Under ether I curetted, and introduced a glass tube containing fifty milligrams of pure radium bromide for ten minutes. This would have produced a sharp reaction upon the skin. She progressively improved, menstruated normally, and recovered her health. In one year the tumor was perceptibly smaller. I again applied radium, sixty milligrams for fifteen minutes. During the following year I applied it again, on one occasion forty-five minutes and on another ten minutes, thus feeling my way along carefully to ascertain the safe and efficient dosage. The flow had ceased wholly and the tumor slowly reduced to an insignificant remnant. The patient has remained in perfect health ten years."

"I ventured now to apply it for a longer period, hoping to get quicker results. A lady of forty-nine years had refused operative treatment for growing fibroids which at last had caused increasing severe hemorrhages, lasting sometimes three weeks. In June, 1909, I introduced into the uterine cavity sixty milligrams of pure radium bromide * * * * and left it two hours without filter. On the following day I again introduced it further than before so that it reached the fundus, the canal being a deep one. The tumor formed a broad mass extending from one iliac spine to the other, so that a finger could not be pressed down between it and the bone. The flow diminished and stopped in three months. A short flow came again, and I made one more application of one hour. In one year there was a marked reduction in the mass of tumor. The flow had stopped entirely. Each year the mass grew smaller, until it became wholly insignificant. The patient meanwhile enjoyed perfect health, and a recent examination shows the tumor practically gone."

"Before speaking of later cases it is of interest to note the enthusiasm with which Drs. Kelly and Burnham have recently adopted this method in a recent report of twenty-one myoma patients."

"It will surprise only those who have not witnessed the energetic action of radium to know that so small a tube of this powerful agent can exert a restraining alterative force. The beauty of its application to so deep a cavity, unapproachable from within by X-rays, is manifest. But that its action resembles that of a Roentgen tube is worth a moment's explanation."

"It has recently been demonstrated by Kroenig and Gauss that an intense, costly and almost dangerous use of penetrating X-rays from without, is capable of arresting menorrhagia and causing absorption of a fibroid tumor."

"The gamma rays from radium, as also from the X-ray tubes, are the deep penetrating force, but in themselves they do not effect the repression of tumor cells. This is brought about by the beta rays only. These are generated in the tissue through impact of gamma rays with all substances through which they are passing. The liberated beta electrons are immediately brought into action. These have been proved to be the efficient agent. (See Medical Record, Nov. 28, 1914)."

"In addition to the intense far-reaching gamma radiation, we have

also from radium an immense local exhibition of beta radiation close to the tube, which is absent in X-ray tube treatment. This has the tremendous advantage of local effect on the bleeding lining of the uterus. Its effect on the hypertrophied tissue is, to speedily bring about vascular blockade, lymph filtration and cell retrograde, followed by restoration to healthy conditions."

"For years I have applied radium which is contained in very thin glass tubes, containing it in either vulcanite, silver, lead or gold holding tubes, to filter out somewhat the soft beta rays, which are restrained by one-tenth of a millimeter of lead. But, better than all, are celluloid holders of the size and thickness of an ordinary goose quill. These offer little barrier to the passage of the beta rays, protect the radium, and can be sterilized. I have had them made for me by the thousand at slight cost, and do not use them twice. The length is ten centimeters, but two can be joined by wrapping adjoining ends with three or four turns of chiffon sealed by collodion. Thus, in a deep uterine canal purified radium tubes can be held in contact with every part. It can be easily inserted in a tortuous canal where a straight silver holder might do damage. It is only necessary to compress the celluloid tube between the contained radium tubes and a jointed tube is formed adapted to the bends in the canal and can be safely pushed in."

"In the case illustrated profound anemia from almost continuous hemorrhage was exhausting the patient. Without anesthesia, the cervix was purified by iodine, and a sound passed six inches into the cavity, which bled four ounces from the probing. This was at once checked by the smooth, long radium tube, containing fifty milligrams radium element, kept in two and a half hours. It was followed in four days by one hundred milligrams radium element in a very long tube which remained in for two hours."

"This method seems to me to afford the maximum benefit with the maximum simplicity."

"In the early intrauterine use of radium for fibroids, I felt the need of great caution and used moderate treatments at long intervals. Every new case treated has given me greater confidence in the use of larger doses and less frequent application. From my experience to date, I am of the opinion that speedy and wonderful results can be obtained by using from fifty to one hundred milligrams (radium element) in concentrated form in tubes placed in thin, smooth applicators without filter for one application of two hours. If, after two months, hemorrhage recurs, that may be repeated. The first concern is to stop bleeding. Incidental benefit comes from slow shrinkage of the tumor. Every six months examination will reveal its diminution. In some cases entire disappearance follows."

"Thus far one may say that ten years' experience has demonstrated to me the persistence of good effect in menorrhagia of fibroids. The uniform reduction of tumors follows the prompt and permanent arrest of hemorrhage. I am inclined to think it wiser to obtain slow reduction by treatment as above indicated rather than by any more intense radiumization looking for extremely rapid disappearance. This caution may favor the preservation of a healthy uterine mucous lining which, to a woman desiring maternity, would be better than to risk cicatricial tissue which might replace a too violently altered membrane."

"During twelve years my radium work has been divided in interest in all fields of surgery, and I have continued to offer myomectomy or hysterectomy to the greater number of cases presenting themselves, but

I am now convinced of the efficacy and brilliant results of this painless and innocent use of radium in such cases. I regard it as the procedure of choice in all cases except pendunculated fibroids."

"In all I have followed twelve typical and severe cases with the results demonstrated in this paper, and am satisfied the treatment of fibroids and menorrhagia has entered upon a new era."

* * * * *

A. C. Morson. Treatment of Malignant Disease by Radium Irradiation. British Journal of Surgery, No. 7, p. 351. "The effect of exposing malignant cells to radium irradiation, according to Morson, is as follows: 1. Rapid degeneration of the malignant cells in the immediate vicinity of the tube of radium. 2. Apparent vacuolation and enlargement of nuclei of those cells beyond the degeneration zone. 3. Loss of the reproductive function of the cancer cell. About the third day after treatment the connective-tissue cells commence to proliferate. The action of radium on the connective-tissue cells shows a similarity to the attempt of nature to arrest the growth of cancer through new formation of fibrous tissue. If an excessive quantity of radium or too prolonged an exposure be given, not only necrosis of the whole tumor results, but the normal tissues slough also. Owing to the sensitiveness to irradiation of the endothelium which lines blood vessels, thrombosis is liable to occur. The vascular supply of the malignant tumor may thus be interfered with."

"The microscopic changes which have been described can only be detected when the malignant cells are exposed to the rays in the body. The author has made experiments with a view to finding out whether by irradiating tumors outside the body it is possible to detect similar changes. Portions of growths suspended in the patient's blood immediately on removal have been submitted to irradiation for twenty-four hours at body temperature. No differences in microscopic appearance were observed between these and the controls, which were kept under similar condition but not irradiated. When a malignant tumor has apparently disappeared after radium treatment, a thickening of the tissues, due to proliferation of the connective-tissue cells, is found to have taken place. If the treatment has been successfully carried out, no active inflammatory changes are detectable. In the normal tissue there is a marked increase in sensitiveness to irradiation when radium is applied a second time. Pigmentation of the skin and telangiectases are common sequelae of radium irradiation. No evidence has yet been brought forward to show that diminution in size takes place in visceral skin or bone mestastases after removal of the primary growth by radium treatment. In a few cases, however, a decrease in the size of the gland metastases has been observed." Journ. A. M. A.

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C. Pellizzari. Radium Treatment of Carcinoma of the Rectum. Riforma Medica, March 20, 1915. "In a case of cylindrical adenocarcinoma of the rectum treated by radium, the patient, a man aged fifty-seven years, was considered inoperable, being cachectic, dropsical, and febrile. Radium applications were begun in April, 1913, with twenty, and later, thirty mgm. of radium bromide. This resulted in noteworthy diminution of the size of the tumor, a return of regular intestinal function and an increase of twelve kilograms in weight. During the year following, a second series of applications were made in conjunction with twenty-four intravenous injections of enzitol. At present the patient has only a slight tumor on the intestinal wall which microscopically shows only a few traces of neoplastic infiltration." N. Y. Med. Journ.

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H. Futh and F. Ebeler. Radiotherapy of Cancer. Zentralblatt fur Gynakologie, XXXIX, No. 14, p. 17. Futh gives his experiences with 56 cases of uterine cancer given radium or Roentgen treatment including 22 absolutely inoperable cases and 11 in which prophylactic treatment was given to ward off recurrences. In 53 per cent. of 45 women given radium treatment, no general disturbance was noted from the measure, but the others showed more or less physical depression and in nine cases there was a considerable loss of weight. The effect on the bladder and rectum is the most disagreeable by-action of this radium treatment; 10 women had severe tenesmus in bladder or rectum, including two who had imperious desires to urinate every five or ten minutes. The patients complained very much of these bladder and rectum disturbances and were materially depressed by them. They proved transient as a rule, but kept up for eight days in two cases. In two cases the prolonged radiotherapy entailed a stricture in the rectum. In two other cases pyometra developed and in another case a secondary abscess in the thigh. On the whole, they conclude, radiotherapy constitutes great progress in treatment of cancer. They advise it with confidence although without too much optimism. All the 10 operable cancers have retrogressed entirely or nearly so. Six of the inoperable patients are clinically cured, but not much benefit was realized in the ten cases of inoperable recurrence. Journ. A. M. A.

SOME EXPERIMENTS ON THE QUANTITATIVE DETERMINATION OF RADIUM*

HERMAN SCHLUNDT, PH.D.

The accurate determination of radium in radium-bearing ores is generally conducted by the emanation method. With proper care the method is very certain and delicate. It is based upon the fact that the gaseous disintegration product of radium, the emanation, can be completely separated from radioactive materials, and that the equilibrium quantity is proportional to the content of radium. The minute quantities of radium emanation concerned in quantitative determinations of this kind are capable of exact measurement by electrical methods. The emanation is introduced into an air-tight electroscope or an ionization vessel connected with an electrometer, and the saturation current produced, under proper conditions, is proportional to the quantity of radium in the specimen from which the emanation was separated. The measuring instruments are standardized by means of known quantities of emanation from a standard radium solution, or from weighed amounts of uraninite or some other uranium-bearing mineral not of secondary origin, whose uranium content is known. In standardizing electroscopes by the latter method the radium content of the mineral is obtained by multiplying its uranium percentage by the proportionality factor 3.4×10^{-7}.

In the assay of radium ores the complete separation of the emanation from the specimen under examination is of course absolutely essential for accurate work. The collection and subsequent transfer of the gas is largely a matter of careful manipulation. The work of various investigators has shown that heating even to a white heat rarely expels all of the emanation from solids. The emanation, however, is completely liberated from the ore by dissolution and boiling. For substances soluble

*Transactions of the American Electro-chemical Society, Vol. 26, pp. 163-171, 1914.

in water or acids several forms of apparatus for the quantitative separation of the emanation have been described.[1]

Rocks and minerals that do not dissolve in acids upon heating, or are only partially soluble in them, require different treatment. One of the standard methods, known as the solution method, consists in fusion of a definite quantity of the material with four to five times its weight of mixed carbonates of sodium and potassium. The fused mass is lixiviated with water and washed with dilute sodium carbonate solution. The insoluble residue is dissolved in dilute hydrochloric acid. The alkaline and acid solutions are placed in separate flasks which are corked. On standing for a month the equilibrium quantity of emanation is again produced by the radium in solution. The emanation is then separated by boiling, and transferred to an emanation electroscope, and after three hours, when the activity is a maximum, the saturation current is measured.

Recently Joly[2] and others have introduced fusion methods which appear to be more reliable than the solution method. The emanation is released from the rock by fusing it with a suitable flux—mixed carbonates of sodium and potassium are generally used—in a closed, electrically heated furnace at a temperature of over 1,000° C. The liberated emanation is collected, and after being freed from carbon dioxide, is transferred to a standardized electroscope for measurement.

The results obtained by the fusion method are generally higher than the values by the solution method. In the solution method it is difficult to avoid the formation of slight precipitates in the solutions, and these doubtless cause the separation of some radium, which does not release its emanation completely upon boiling.

An electric furnace of the Joly type would serve very well for the assay of radium ores that are not completely soluble in boiling acids, and it would be particularly well suited for ores of very low grade, as charges of thirty grams can be readily fused in the ordinary size of furnace. The furnace, however, is of special design, a large platinum crucible is required as well as heavy platinum wire for the heating resistance. Various electrical measuring instruments and other electric accessories are desirable parts of the equipment. On the whole, the apparatus of Joly is rather expensive equipment for an assay laboratory. Our experiments were directed toward devising and testing the accuracy of a simple fusion method for the assay of even low-grade radium ores, that can be conducted with inexpensive apparatus.

We have found that charges as large as twelve to fifteen grams can be successfully fused in hard glass test tubes made of combustion tubing of large bore. The method will thus serve for the determination of radium in very low-grade ores. The specimen of carnotite ore used in our experiments had a radium content equivalent to only 0.6 percent uranium. A two-gram sample of the ore when fused with ten to twelve grams of mixed sodium and potassium carbonates furnishes sufficient emanation for an accurate determination, notwithstanding the fact that the continuous loss of emanation under ordinary conditions is over 40 percent. A fusion tube in the form of a test tube 25 centimeters long affords ample space for a 12-gram charge. The open end of the tube is fitted with a two-hole rubber stopper carrying glass tubes, one of which extends down the tube to within a few centimeters of the charge. One of the tubes is closed during a fusion and the other is connected to an absorption tube and a special form of gas burette of about 200 cc.

[1] The forms of apparatus used by Strutt, Boltwood, McCoy, Schlundt and Moore, are illustrated and described by Randall, Trans. Am. Electrochem, Soc., **21**, 463 (1912).

[2] Joly, Phil. Mag. **22**, 134 (1911).

capacity connected with a leveling reservoir. The apparatus (Fig. 1) used for collecting the gas was of the form used by Moore and the writer, and by Randall in the estimation of radium by the method of boiling. The flask *A* is not used in the fusion method and the clip at *E* is therefore closed. The fusion tube is attached on the side *T*. In most of the experiments the absorption tube contained a few pieces of sodium hydroxide and a sufficiently small volume of water to permit the back flow of gas without drawing liquid into the fusion tube. For smaller charges side neck tubes of smaller bore were used. Such tubes are easily made from combustion tubing in an oxygen-gas flame. In some of the experiments hard glass tubes drawn out to a tip were used. After fusion is completed the emanation in the tube can then be transferred to the electroscope by simply breaking the tip and passing a current of air over or through the melt. In the decomposition of ores by boiling with concentrated sulfuric acid, the fusion tube was replaced by a round-bottom flask of about 100 cc. capacity. When fluxes evolving oxygen were used the absorption tube was replaced by a hard glass tube containing copper gauze which was heated during fusion.

In conducting a determination the gas burette is first filled with freshly boiled water. The fusion tube containing its charge is attached at *T* and the other outlet of the tube is closed. All of the glass stop-cocks

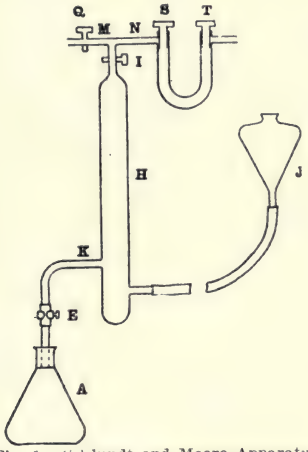

Fig. 1. Schlundt and Moore Apparatus.

except *Q* are then opened and leveling reservoir is lowered to the position shown in the figure. Any air leak in the apparatus is thus readily detected. The fusion tube should be inclined slightly upward from the horizontal so that the melt will flow toward the closed end. Freshly heated fluxes should be used and the entire tube should be warmed first to minimize the danger of reflux water drops cracking the tube. During fusion the water level in the reservoir is adjusted from time to time and is always maintained at a little lower level than the water in the burette. A slight excess external pressure is thus maintained on the fusion tube during heating, until it gradually collapses at the hotter parts. The heating is done with a large-size Meker burner aided by a hand blast lamp. The heating of the melt is continued for fifteen minutes. When the

fusion is made with mixed carbonates there is a small, steady evolution of gas all the time during the heating as the result of the action of the flux on the glass tube. This continuous evolution of gas doubtless serves a very useful purpose in removing the emanation from the melt. In our experiments with a carnotite concentrate consisting largely of calcium sulphate, a little powdered quartz was added to the charge to increase the evolution of gas during fusion.

While the tube is still hot an exhausted electroscope is attached at *Q*, and the gas in the burette is drawn into the electroscope until water reaches the tube *MN*. The stopcock *1* is then closed and the inlet tube of the fusion tube is opened. The remaining gas in the tube and absorption train are thus swept into the electroscope.

Three hours after the introduction of the gas into the electroscope the ionization current raeches a maximum value which remains constant for nearly half an hour. Readings are made at this time to determine the rate of discharge. By keeping the leaf charged from eight to ten minutes before readings are to be made very uniform rates of discharge are obtained.

Two electroscopes were used in our experiments. One was a gold leaf instrument[3] and the other a Wulf quartz fiber electrometer.[4] In using the Wulf instrument it was found that the ionization chamber can withstand pressures of two-thirds of an atmosphere. The gas was therefore introduced directly into the exhausted chamber and the circulation method recommended by the inventor was not used. Both instruments were standardized by means of known quantities of radium emanation separated from weighed amounts of uraninite containing 53.03 percent of uranium. The emanation was separated in a small flask like *A*, Fig. 1, by dissolving in nitric acid (1 : 1) and boiling. The flask in these calibration experiments was fitted with a two-hole rubber stopper, one of which held a small drop funnel.[5] Our specimen of uraninite continuously emitted 2.6 percent of its emanation at room temperatures. We have adopted the plan of keeping on hand a stock of weighed samples to be used for calibrating electroscopes, stored in the small flasks at least a month before boiling off the emanation. The total equilibrium quantity of emanation is thus obtained.

As most radioactive solids continuously emit a portion of their emanation at room temperatures, the quantity of emanation released by fusion or boiling is less than the equilibrium quantity. The emanation loss in the cold was determined by enclosing a definite weight of the powdered ore, ground to pass through an eighty mesh sieve, between layers of cotton in glass stoppered U tubes, and allowing the emanation to accumulate for a definite time—a period of four days or more. Then by drawing air through the tube into an emanation electroscope the fraction continuously emitted can be readily deduced. The equilibrium quantity of emanation that will accumulate in the tube was calculated by the equation:[6]

$$E_t = E\,(1 - e^{-\lambda t})$$

where E represents the quantity found after t hours of storage; E the maximum quantity that will accumulate, e, the base of the natural logarithms, and λ, the radioactive constant, 0.0075 $(hr)^{-1}$. To ascertain

3The instrument is illustrated and described in Randall's paper, Trans. Am. Electrochem. Soc., **21**, 477.

4Wulf, Physik. Zeitschrift, **8**, 246, 527; **10**, 251.

5For details of operation see Schlundt and Moore, Jour. Phys. Chem., **9**, 320 (1905).

6Rutherford, "Radioactive Substances and Their Radiations," (1913) pp. 336, 665. Kolowrat, Le Radium, **6**, 195 (1909).

whether samples taken from stock in closed bottles still retain a part of their emanation, after a few minutes of exposure during weighing, several samples were weighed out and placed in U tubes and then air drawn through them immediately into an electroscope. No increase in the rate of discharge of the leaf was observed.

The fusion method of determining radium described above was tested with four radioactive solids: (1) The specimen of uraninite used in calibrating the electroscopes; (2) A composite of a carnotite concentrate which had been obtained from carnotite ore on a commercial scale by the Fleck method.[7] The concentrate consists largely of calcium sulphate; (3) A specimen of low-grade carnotite ore from the Paradox Valley, Colorado; (4) A spring deposit (sinter) from Doughty Springs, Colorado. The material is a unique spring deposit in that it consists of about 87 percent barium sulphate. This specimen was kindly sent by Dr. Headden of the State Agricultural College of Colorado, who first described this interesting group of radioactive springs.[8]

The radium content of these specimens is given in the fourth column of Table I; the uranium equivalent appears in the last column; and in the second and third columns are recorded the percentages of the equilibrium quantity of emanation emitted at ordinary temperatures and at red heat. The radium content of the uraninite was deduced on the assumption that radium and uranium exist in equilibrium in the specimen. For the analysis of the sample the writer is indebted to Dr. Randall.[9]

TABLE I.
Results of Analyses.

Substance	Percent of Cold Emanation Loss	Percent of Emanation Loss at Red Heat	Ra per g. x 10^9	U per g. x 10^9
Uraninite	2.6	25.6	180.2	530.3
Carnotite concentrate	18.1	88.6	24.24	21.3
Carnotite ore	41.8	90.	20.77	6.11
Spring deposit	2.8	30.	16.54	4.57

The results obtained for the radium content of the four substances by different methods of separating the emanation, and by means of different fluxes, are given in Tables II, III, IV and V. The numbers in the first column indicate the number of determinations that were averaged to give the values in the third and fourth columns.

TABLE II.
Uraninite.

Number of Experiments	Method of Separating the Emanation	Grams Radium per g. x 10^9	Grams Uranium per g. x 10^9
9	Solution in nitric acid and boiling	180.2	53.03
6	Fusion with mixed carbonates	179.2	52.7
2	Fusion with potassium acid sulfate	179.9	52.9
2	Fusion with potassium nitrate	180.9	53.2
2	Fusion with sodium peroxide	180.5	53.1
2	Fusion with potassium chlorate	179.9	52.9
2	Fusion with potassium dichromate	177.1	52.1
2	Heating in hard glass tube	46.6	13.7
2	Boiling with concentrated sulfuric acid	77.2	22.7
2	Fusion with litharge	101.3	29.8
2	Fusion with lead peroxide	136.0	40.0
2	Fusion with borax	165.6	48.7

7Cf. Bulletin 70, Dept. of the Interior, U. S. Bureau of Mines, "A Preliminary Report on Uranium, Radium, and Vanadium," by Richard B. Moore and Karl L. Kithil, p. 74 (1913).
8Headden, Proc. Col. Sci. Soc., 1905.
9Randall, loc. cit.

TABLE III.

Carnotite Concentrate.

Number of Experiments	Method of Separating the Emanation	Grams Radium per g. x 10^{9}	Grams Uranium per g. x 10^{2}
2	Fusion with carbonates, solution and boiling.	19.96	5.87
2	Heating in hard glass tube.....	21.32	6.27
2	Boiling with nitric acid.....	23.05	6.78
5	Fusion with potassium acid sulfate.....	24.24	7.13
4	Fusion with mixed carbonates.....	24.07	7.08

TABLE IV.

Carnotite Ore.

Number of Experiments	Method of Separating the Emanation	Grams Radium per g. x 10^{10}	Grams Uranium per g. x 10^{3}
2	Fusion with carbonates, solution and boiling.	15.85	4.66
1	Heating in hard glass tube.....	18.65	5.31
2	Fusion with potassium acid sulfate.....	18.63	5.48
2	Boiling with nitric acid.....	18.33	5.39
2	Fusion with mixed carbonates.....	20.77	6.11

TABLE V.

Spring Deposit.

Number of Experiments	Method of Separating the Emanation	Grams Radium per g. x 10^{10}	Grams Uranium per g. x 10^{3}
2	Fusion with carbonates, solution and boiling.	11.29	3.38
2	Boiling with concentrated sulfuric acid.....	13.97	4.11
2	Heating in hard glass tube.....	4.93	1.45
2	Fusion with potassium acid sulfate.....	11.02	3.24
3	Fusion with mixed carbonates.....	16.54	4.57

The results of the foregoing tables point to the following conclusions:

1. The solution method, that is, fusion with mixed carbonates, followed by solution and boiling, gave results that are only 70 to 80 per-cent of the values obtained by the fusion method with mixed carbonates.

2. Fusion with mixed carbonates appears to be superior to fusion with potassium acid sulphate, although with the carnotite concentrate a slightly higher value was obtained with the sulphate.

3. Fusion with borax probably gives low values as a result of the retention of some of the emanation in the melt. At the temperatures attained in our experiments the evolution of gas and its flow through the melt is necessary for complete release of the emanation.

4. High emanating power in the cold indicates a large release of emanation by heating. In the case of the specimen of carnotite ore a rough assay may be made by merely heating the ore to bright redness.

5. A complete separation of the emanation from uraninite is obtained by solution in nitric acid and by fusion with some of the ordinary fluxes.

No experiments were conducted with the fusions to ascertain whether the equilibrium quantities of emanation can be again separated by a subsequent fusion. Experiments of this kind have been conducted in this laboratory during the past year by Dr. W. G. Brown and Mr. O. E. Sheppard in connection with an extensive series of experiments with a Joly furnace on the radium content of rocks.

Chemical Laboratory, University of Missouri.

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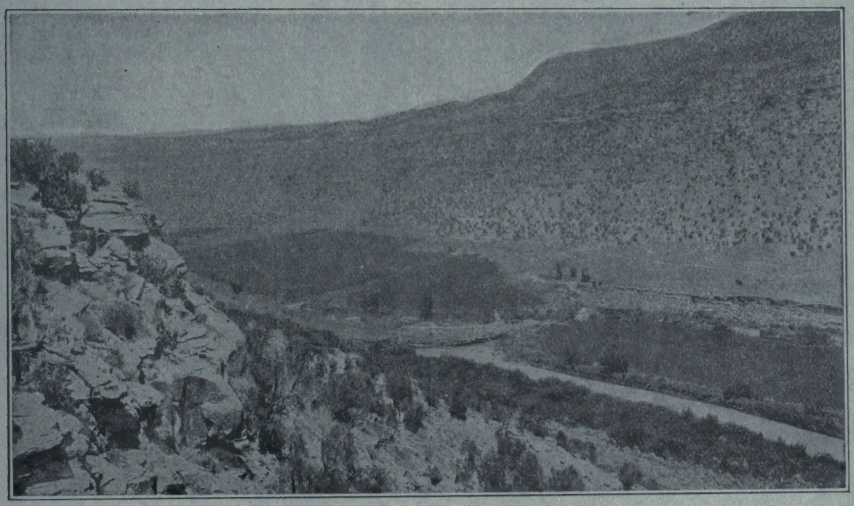

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PREPARATION	*Radium Element Content*	*Radium Emanation accumulated in 30 days (equilibrium amount)*
Radium Solution for Drinking... ("Standard")	2 Micrograms	2 Microcuries (5,400 Mache Units)
Radium Solution for Intravenous Use (Ampulles) ..... ("Standard")	50 Micrograms	50 Microcuries (135,000 Mache Units)
Radium Solution for Intravenous Use (Ampulles) ..... ("Standard")	100 Micrograms	100 Microcuries (270,000 Mache Units)

40 to 50% of any quantity of radium element, intravenously used, is eliminated in the first 10 days. The remainder is eliminated at a daily rate of less than one per cent. of the radium present, and may be held constant in quantity by administering one bottle of "Standard Radium Solution for Drinking," every two to four days, depending upon the amount of radium first used.

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